DETECTION OF THE (O III) 88.16μ LINE IN M17

by

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ABSTRACT

The (OIII) 88.16μ line has been detected in the galactic H II region M17. The line intensity is $2.2^{+1.0}_{-0.7} \times 10^{-15}$ watts cm^{-2}.

Subject Headings: infrared
forbidden lines
interstellar matter

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Introduction

Far infrared line emission from H II regions has been predicted by a number of authors, including Petrosian (1970) and Simpson (1975). We wish to report the detection of one of the predicted transitions, the fine structure line of O III at 88.16μ. The line was seen in emission from M17 (the Omega Nebula), which is an optically bright galactic H II region and a strong thermal radio source (Terzian and Balick, 1974).

Observations

The observations were made during April 1975, using the 30 cm telescope of the NASA Lear Jet. The aircraft was flown at an altitude of 13.6 km, several kilometers above the tropopause.

The instrument employed was a liquid helium cooled grating spectrometer with Ge:Ga photoconductive detectors (Moore and Shenker, 1965). It had a system NEP* of roughly 9×10^{-13} watts $Hz^{-1/2}$ during observations. The entrance slit was rectangular, yielding a beam subtending roughly 4 x 5 arc minutes on the sky, and giving a bandpass of 1.3 microns. The oscillating secondary of the Lear telescope was run at 30 Hz, with a 10 arc minute beam separation.

The observational procedure was similar to that followed in earlier observations (Ward, 1975). Observations were made

* Noise Equivalent Power

of Venus, M17 and the moon, and the results are plotted in Figure 1, along with results obtained previously for M42 (Ward, 1975).

The spectra shown in Figure 1 are not corrected for atmospheric transmission or instrumental profile. However, in order to make direct comparison simpler, the raw spectra have been divided by blackbody functions of appropriate temperatures to remove the overall slopes. Also, the spectra have been normalized to the same scale. The blackbody temperatures used were 390 K for the moon (Linsky, 1973), 245 K for Venus (Chase et al., 1974), 75 K for M42 (Ward, 1975) and 80 K for M17 (Harper, 1974). Over this short range of wavelengths, errors in the temperatures are not critical.

A number of spectra were taken during observations of each object, and these were normalized to remove small air mass effects, then averaged to obtain the spectra shown. The error bars are one standard deviation, derived from the variance of the mean of the data points at each grating position. The major noise component was guiding noise.

The M17 spectrum shows a strong feature at 88.1μ, more than 8 sigma above the neighboring points. This feature appeared in all seven individual spectra. The atmospheric transmission at this wavelength is quite smooth, as can be seen from the other spectra plotted. We suggest that this feature is the (O III) 88.16μ line.

The strong absorption feature seen at 90μ is due to atmospheric water vapor. This feature is broader and shallower

in the lunar spectrum because the spectrometer has a slightly wider bandpass for sources like the moon which uniformly fill the entrance slit.

During the observations of M17 we guided on a position which gave the maximum continuum flux. To obtain the line intensity I_L for this region, we use

$$I_L = \frac{S_L}{S_c} F_c \, \Delta\lambda$$

where S_L is the line signal, S_c is the continuum signal, $\Delta\lambda$ is the spectrometer bandpass, and F_c is the continuum flux per unit wavelength interval. Using a continuum flux value of 4.6×10^{-15} watts $cm^{-2}\mu^{-1}$ derived from the results of Harper (1974), who used a beam of roughly the same width as ours, we get a line intensity of $2.2^{+1.0}_{-0.7} \times 10^{-15}$ watts cm^{-2}.

A major part of the uncertainty in the calculated value is due to the possible error in F_c, which can be as much as 25% according to Harper (1974). Other important sources of uncertainty are possible errors in the wavelength calibration, the line and continuum signal levels, and the bandpass.

Discussion

Searches for the (O III) 88.16μ line have now been carried out in M17 and M42 (Ward, 1975). The results of these searches are compared to theoretical predictions in Table I below. The predicted intensities have been scaled to our beam size. Only approximate values are given for M17 -- we have derived these values from the M42 predictions

following a procedure given by Petrosian (1970).

Table I. Predicted and Observed Intensities for (O III) 88.16

Source	Predictions: Intensity (watts cm^{-2})	Predictions: Reference	Observations: Intensity (watts cm^{-2})	Observations: Reference
M42	3.9×10^{-15}	Petrosian (1970)	$< 2 \times 10^{-15}$	Ward (1975)
	1.4×10^{-15}	Simpson (1975)		
M17	$\sim 6 \times 10^{-15}$	Petrosian (1970)	$2.2^{+1.0}_{-0.7} \times 10^{-15}$	this paper
	$\sim 2 \times 10^{-15}$	Simpson (1975)		

The values obtained from Petrosian are substantially higher than the observed values for both M17 and M42. Simpson's result for M42 is in agreement with the observed upper limit, and the approximate value for M17 derived from her M42 result agrees quite closely with the observed intensity. She made her prediction for M42 using a model derived from optical forbidden line observations and radio continuum data (Simpson, 1973). This model has a lower oxygen abundance and a higher central density than the model used by Petrosian for M42.

Detection of the (O III) 88.16μ line is really only the first step toward using the far infrared fine structure lines

as an astronomical tool. Petrosian (1970) among others has pointed out that these lines can be used to determine electron densities and abundances of ions in regions which are inaccessible to optical observations. Unfortunately aircraft observations of many of these lines may prove to be excessively hindered by atmospheric transmission difficulties. A number of the more interesting lines are very close to strong atmospheric water vapor lines which may block them out entirely at aircraft altitudes. Examples are the (C II) 156.2μ line and the (O III) 51.69μ line. The potential usefulness of these lines will probably only be realized through observations with instruments carried above the atmosphere in balloons or satellites.

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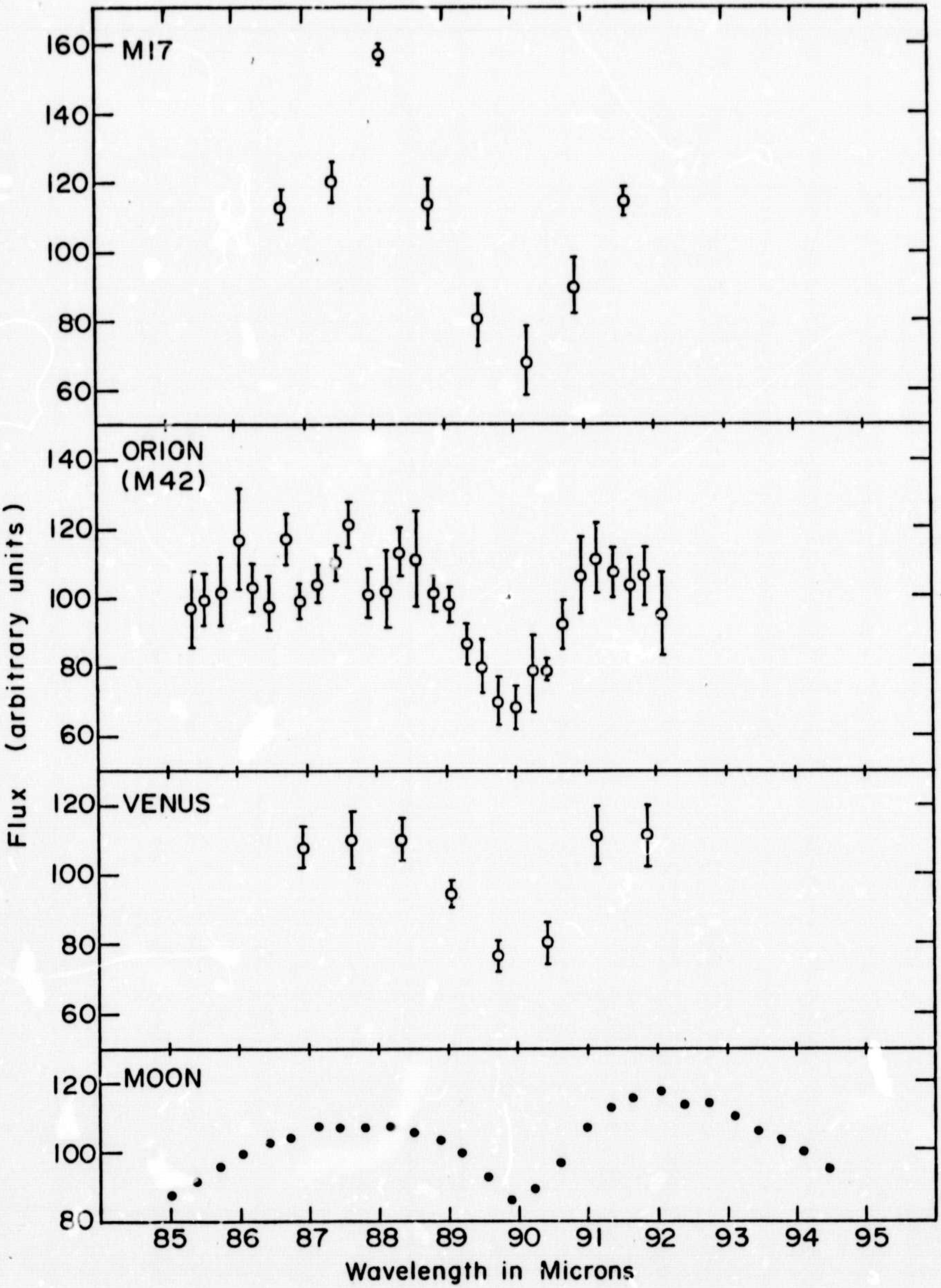
Figure Caption

Figure 1. Raw spectra of M17, M42, Venus and the moon. The spectra have been normalized to the same scale and overall slopes have been removed by division with appropriate blackbody functions.



M17
ORION (M42)
VENUS
MOON
Flux (arbitrary units)
Wavelength in Microns
160
140
120
100
80
60
85
86
87
88
89
90
91
92
93
94
95